Revue suisse de Zoologie 111 (3): 551-562; septembre 2004

An enigmatic cave-dwelling ground beetle: *Trechus barratxinai* Español, 1971 (Coleoptera, Carabidae, Trechinae, Trechini)*

Vicente M. ORTUÑO
Departamento de Biología Animal, Facultad de Biología, Universidad de Alcalá, E-28871 Alcalá de Henares, Madrid, Spain. E-mail: vicente.ortuno@uah.es

An enigmatic cave-dwelling ground beetle: *Trechus barratxinai* Español, 1971 (Coleoptera, Carabidae, Trechinae, Trechini). - An important population of *Trechus barratxinai* Español, 1971 was discovered in the Penyes de Roset, near the type locality (abyss of Barratxina, Xixona-Alicante, East Spain). This species, originally considered as cavernicolous, shows epigeal and lapidicolous life habits, as now discovered. A detailed laboratory study revealed the presence of wings which had been overlooked in the concise description of the species. The development of wings confirms the suspicion that, as in other species in this genus, *T. barratxinai* has geophilic, lucifugous and hygrophilous habits but is not a cavernicolous (troglobiont) species. The species description is completed with details on the anatomy of the female genitalia. Also, the taxonomic position of *T. barratxinai* is questioned and its position within the "*T. austriacus*-group", near *T. diecki* Putzeys 1870, its geographical neighbour, is proposed. Finally, the first data on the species biology and on its habitat characteristics are given.

Keywords: Carabidae - *Trechus* - redescription - systematics - ecology - caves - Iberian Peninsula.

INTRODUCTION

Trechus Clairville, 1806 is a large genus, including more than 500 species (Casale *et al.*, 1998), with new ones being discovered every year. Presently it is known from the Holarctic region and East Africa. From the Iberian Peninsula 49 species are recorded (Serrano, 2003); of these, 18 have strictly hypogeous life with morphological adaptations to the subterranean environment, but only 14 of these species are known exclusively from caves. As for the Spanish-Levante fauna, the following are the known hypogeous *Trechus* species, all of them limited to the Alicante province: *T. martinezi* Jeannel, 1927, *T. alicantinus* Español, 1971, *T. beltrani* Toribio, 1990 and *T. barratxinai* Español, 1971. The first three species belong to the same species group, whilst the position of *T. barratxinai* is enigmatic, it only has been found once in the abyss of Barratxina in Xixona (Alicante, Spain). The citation of the species in the Cave of the

* This work has been funded by the Ministerio de Ciencia y Tecnología within the "Ramón y Cajal" plan.

Manuscript accepted 04.02.2004

Farallón, Riópar (Albacete, SE Spain) (Lencina *et al.*, 1990) probably refers to an undescribed species of *Trechus*. Español (1971) placed *T. barratxinai* into the *planipennis-pandellei*-group (*Trechus pyrenaeus*-group and *Trechus pandellei*-group *sensu* Jeannel, 1927). The author asserts that this species is the first cave-dwelling of the mentioned group, whereas other species of the group are epigeous and more or less orophilous. Neither its status as cavernicolous species (Jeanne, 1976; Sendra & Zaragoza, 1982; Zaragoza & Sendra, 1988; Bellés, 1987; Zaballos & Jeanne, 1994) nor the close affinities with *T. planipennis* Rosenhauer, 1856 from Sierra Nevada (Español, 1971) had ever been questioned. Based on new morphological and ecological data the author is reconsidering the affinities of this species within the genus *Trechus*.

MATERIAL AND METHODS

Examined specimens of *T. barratxinai*: 3 males, 2 females, Penyes de Roset, 850 m.s.m., 30SYH17, Xixona (Alicante), 23-3-2003, V.M. Ortuño & J.A. Zaragoza leg. 10 males, 7 females, idem, 7-5-2003, V.M. Ortuño & J.A. Zaragoza leg. 8 males, idem, 15-6-2003, V.M. Ortuño leg. The specimens are deposited in the collection of V.M. Ortuño (Dept. of Animal Biology, Alcalá University, Spain) and 2 males, 2 females in the Muséum d'histoire naturelle Genève (Switzerland) and 1 male and 1 female in the collection M. Toribio (Tres Cantos, Spain).

Also, the following *Trechus* have been examined in this study: *T. martinezi* (three specimens from Cueva de las Maravillas, Alicante; with aborted wings), *T. quadristriatus* (Schrank, 1781) (six specimens from Tres Cantos, Madrid, with functional wings), *T. diecki* Putzeys, 1870 (eight specimens from caves in Andalucía) and *T. planipennis* (two specimens from Laguna de las Yeguas, Sierra Nevada, Granada). Other species of Carabidae (accompanying fauna) have also been studied.

All measurements were made using a calibrated ocular grid set in a microscope and stereomicroscope ocular. The measurements of the wings are summarised in Table I. Two indices proposed by Den Boer *et al.* (1980) were used to estimate relative wing length (RL) and relative wing area (RA): RL = MLW /MLE; RA = MLW x MWW / MLE x MWE (MLW = maximum wing length; MLE = maximum elytron length; MWW = maximum wing width; MWE = maximum elytron width).

The aedeagus was extracted from the abdomen and separated from the tergal apodemal ring; the parameres were separated from the associated membranes in the surface of the median lobe. After examination, genital preparations were included in DMHF (dimethyl hydantoin formaldehyde) and put on over acetate sheet.

A routine procedure was followed to prepare the female reproductive appendages for scanning microscopy. The last abdominal segments of the female were gently squeezed with forceps and introduced in saturated solution of KOH for 8 hours. They then were washed in Scheerpeltz's solution and opened dorsally for checking the alkaline digestion. Staining was carried out with Chlorazol black E® in watery solution for 1-3 minutes under visual control. The excess of dye was removed by washing in KOH and the structures washed again in Scheerpeltz's solution. The dissected structures were placed in a watchglass with Scheerpeltz's solution under a stereo-

microscope with a drawing tube for observation and drawing. Selected dissections were mounted onto a slide and made permanent.

RESULTS AND DISCUSSION

Redescription of *Trechus barratxinai* Español, 1971 (Figs 1, 2, 3a-b, 4a-b)

Diagnosis. Winged species (brachypterous). Macrophthalmic, depigmented with microreticulate integument. Pronotum transverse and slightly cordate: hind angles sharp and sides slightly sinuous in basal margin. Elytra convex, slightly protruding shoulders, with five well-defined striae (the 6th and 7th not very defined, almost missing the striae). Both sexes show similar external morphology, except for the first two segments of anterior tarsus dilated in males. Median lobe of the aedeagus slightly curved; inner piece of median lobe simple. Female genitalia: genital shield with a line of thorn-shape setae on gonosubcoxite; spermatheca long and slender lacking spermathecal gland.

Description. Length: 3,9-4,9 mm (Fig. 1). Head (to anterior end of clypeus) a little wider than long; in dorsal view two deep frontal sulci border ocular areas on both sides and fronto-clypeal area towards the center. Eyes large but not prominent (ocular convexity not very conspicuous). Tempora almost as long as the eyes. Antennae filiform, densely setulose, in particular from 2nd to 11th antennomere. Mandible prominent, sharp. Labial and maxilary palps as typical in the genus. *Cephalic chaetotaxy*: two pairs of supraocular setae (anterior and posterior); two setae at both sides of clypeus (outer one largest); six setae on labrum, lateral setae more elongate; one seta in sulcus of each mandible.

Pronotum one third wider than long, with the sides slightly sinuous in basal half; maximum width slightly anterior the middle half; basal margin rectilinear and smoothly broken toward the rear angles; basal foveae smooth and deep; hind angles sharp and slightly diverging. Disk convex, divided lengthway by central sulcus branching off towards anterior and posterior angles. Lateral channel with regular width. *Pronotal chaetotaxy*: one anterior seta on each side (almost in the first third) and one posterior seta next to hind angle.

Elytra oval-shaped, approximately three times longer than wide; humeral margin well-defined, basally right and perpendicular to the sagittal plane. Disk convex with transverse microsculpture (Fig. 2a); five well-defined striae (1st-5th), the 6th and 7th almost missing. *Elytral chaetotaxy*: marginal umbilical series typical of *Trechus* (humeral area with four equidistant setae; subapical area with four setae, two anterior and two posterior). Each elytron with one setigerous pore beginning at 2nd stria (scutellar pore), two discal setae in the 3rd stria (anterior seta in anterior quarter and posterior setae behind half), similarly subapical seta present at end of 2nd-3rd stria, two smaller ones near apical margin. Elytra with sparse micropubescence (only visible with the microscope).

Short wings (brachypterous species) (Fig. 2b), only a little longer than the elytra (Table I).

Legs long and slender, without special characteristics; foretibia with a longitudinal sulcus; first two tarsal segments of male foreleg dilated.

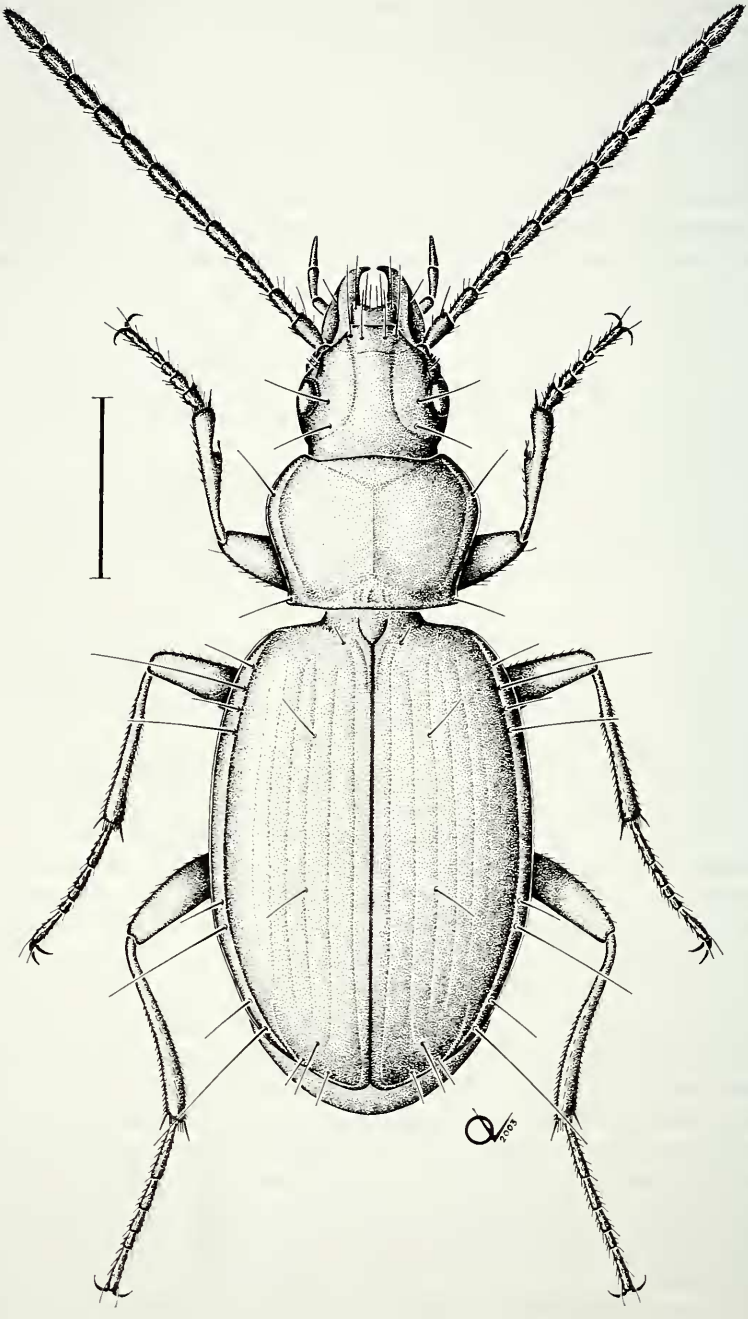

FIG. 1
Habitus of *Trechus barratxinai* Español, 1971 (Scale: 1 mm).

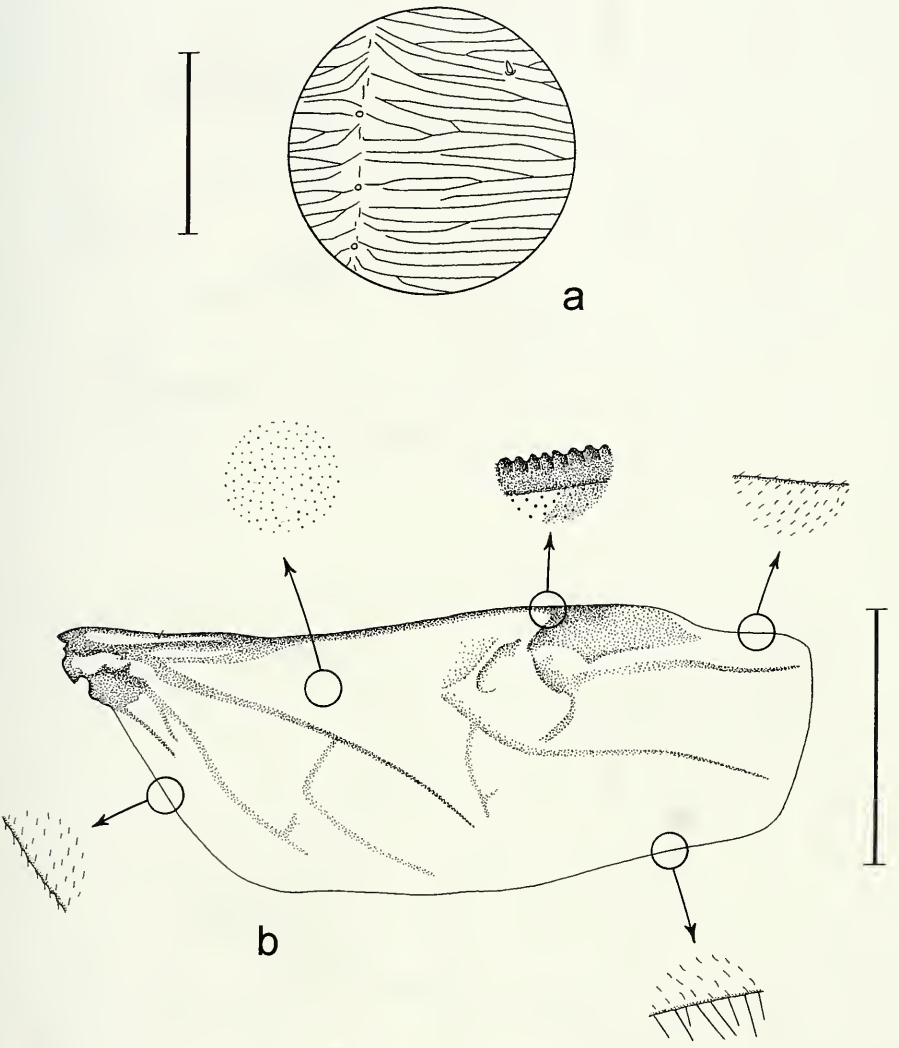

FIG. 2
Morphological details of *Trechus barratxinai* Español, 1971: a) elytral microsculpture; b) wing. (Scale a: 0.05 mm; scale b: 1 mm).

Aedeagus 0.6 mm long, (Figs 3a-b) with the median lobe not very arched; short, thick and blunt apex; apical lamina subsymmetrical. Distal extreme transforming into sagittal lamina. Inner sac very simple with a triangular lamina; there is superimposed a field of spines in the wall of the praeputial tube. Parameres similar, but of different lengths, both tetrasetulose in distal extreme.

Female genitalia (Figs 4a-b): external genitalia formed by dimerous IX gonopods (gonocoxites and gonosubcoxites) and IX laterotergites. Each gonocoxite

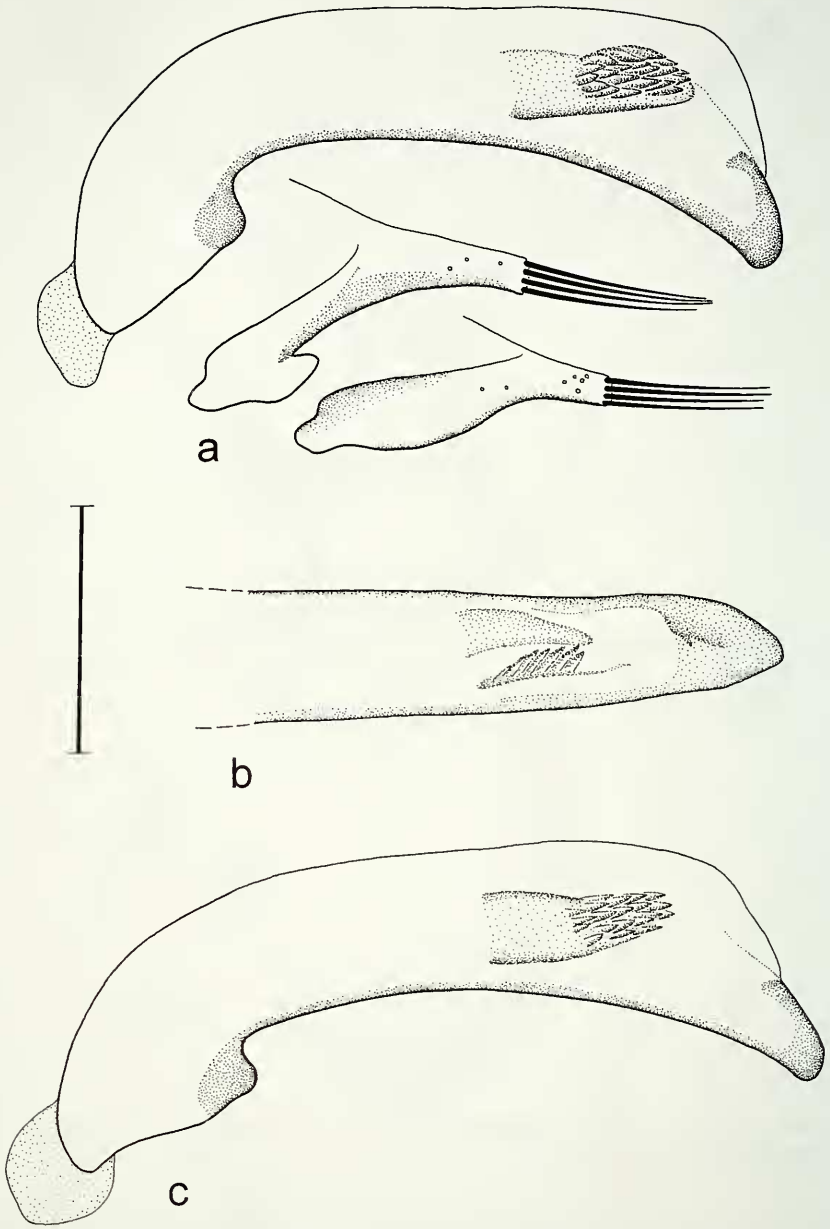

FIG. 3

Aedeagus. *Trechus barratxinai* Español, 1971: a) median lobe, left and right paramere in lateral view; b) median lobe in dorsal view. *Trechus diecki* Putzeys, 1870 from Covadura (Sorbas, Almería): c) median lobe in lateral view. (Scale a,b,c: 0.2 mm).

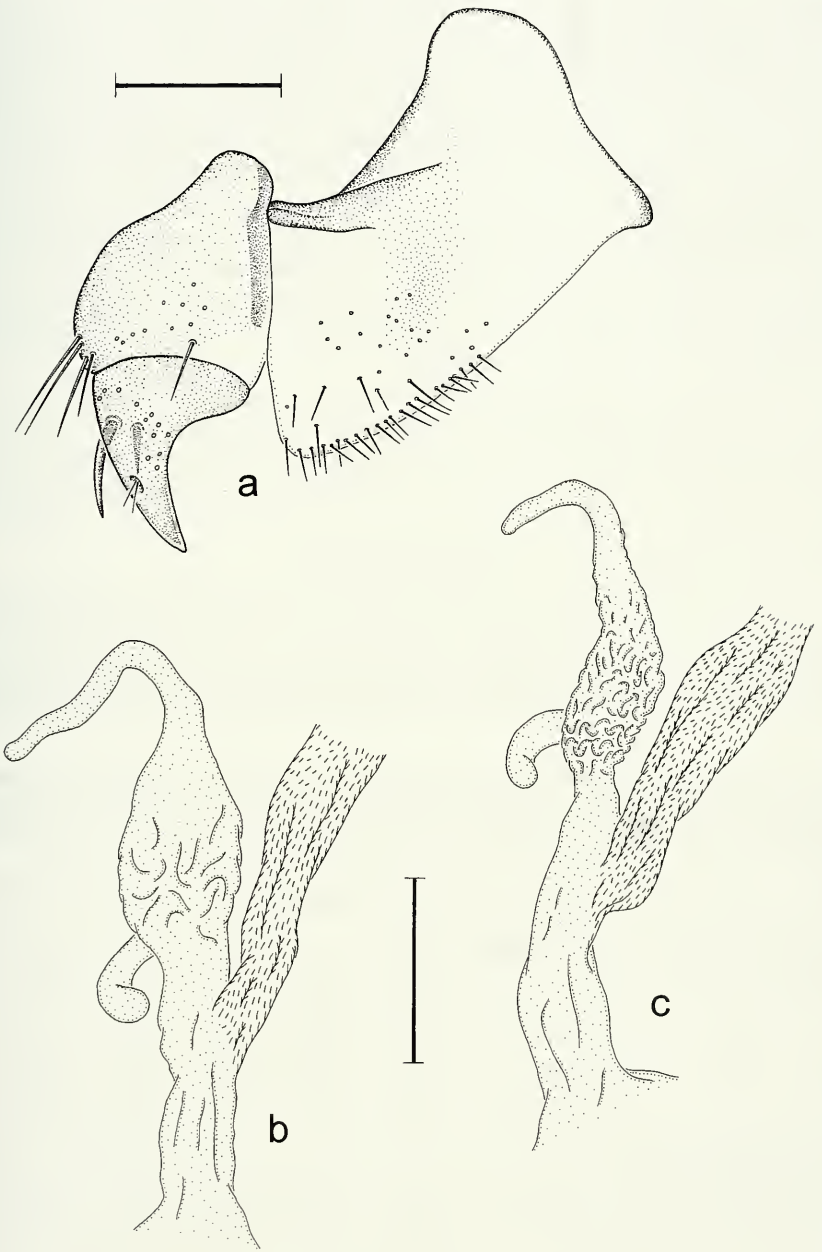

FIG. 4

Female genitalia in ventral view. *Trechus barratxinai* Español, 1971: a) left genital shield; b) spermathecal complex. *Trechus diecki* Putzeys, 1870 from Covadura (Sorbas, Almería): c) spermathecal complex. (Scale a: 0.1 mm; scale b,c: 0.3 mm).

unguiform, with two thorn-shaped setae of considerable size on dorsal surface (the largest located near external edge). Small groove near apex and above ventral surface, with two fine sensorial setae. Gonosubcoxite subtriangular, a little longer than wide and oblique with respect to laterotergite, with four large thorn-shaped setae; smaller setae (1 to 2) found in other areas close to base. Wing-shape, slightly sclerotized IX laterotergite with one group of setae over basal margin (approximately 20) and one more internal group (approximately 6). Internal genitalia completely membranous; tube-shaped vagina-bursa; spermatheca digitiform (long and narrow) with a diverticulum in the basal tract; associate gland absent (spermathecal or accessory gland). The odd oviduct makes contact with spermathecal complex at the same point as where the spermatheca opens, displaying some longitudinal folds; interior densely covered in microfringes.

Variability. Important morphological variations have not been observed, and the same applies to wing development: the relative length and relative area of the wings is very similar in eight specimens randomly selected (5 males and 3 females) (Table I; Fig. 5). Remarkable size differences among imagoes have been observed (see above).

Taxonomic position and biogeographical comments

The overall body shape (tempora, pronotum and basal foveae, elytra) and the development of the wings (brachypterous species) in *T. barratxinai* are discordant with the features of both the *T. pyrenaeus*-group and the *T. pandellei*-group. Also, the aedeagus of *T. barratxinai* is very different from that shown by the species in these

Table I. Values for six quantitative characters used in the analysis of *Trechus* wings. MLW = maximum wing length; MWW = maximum wing width; MLE = maximum elytron length; MWE = maximum elytron width; RL = relative wing length (in mm); RA = relative wing area (in mm^2).

		sex	MLW	MWW	MLE	MWE	RL	RA
Trechus barratxinai	1	female	2.99	1.20	2.81	0.84	1.06	1.52
	2	f	2.81	1.02	2.63	0.98	1.06	1.11
	3	male	2.58	0.80	2.41	0.89	1.07	0.96
	4	m	2.99	0.93	2.54	0.98	1.17	1.11
	5	f	3.03	0.98	2.63	0.98	1.15	1.15
	6	m	3.21	1.16	2.67	1.07	1.20	1.30
	7	m	2.99	1.02	2.63	1.02	1.13	1.13
	8	m	2.67	0.84	2.36	0.93	1.13	1.02
Trechus quadristriatus	1	m	5.26	2.18	2.67	0.84	1.97	5.11
	2	f	5.13	1.96	2.67	0.80	1.92	4.70
	3	f	4.37	1.83	2.41	0.89	1.81	3.72
	4	m	4.68	1.60	2.54	0.89	1.84	3.31
	5	m	5.17	1.91	2.72	0.98	1.90	3.70
	6	f	5.13	1.91	2.63	0.93	1.95	4.00
Trechus martinezi	1	f	0.71	0.31	3.97	1.29	0.17	0.04
	2	f	0.75	0.35	4.01	1.33	0.18	0.04
	3	m	0.71	0.35	4.06	1.33	0.17	0.04

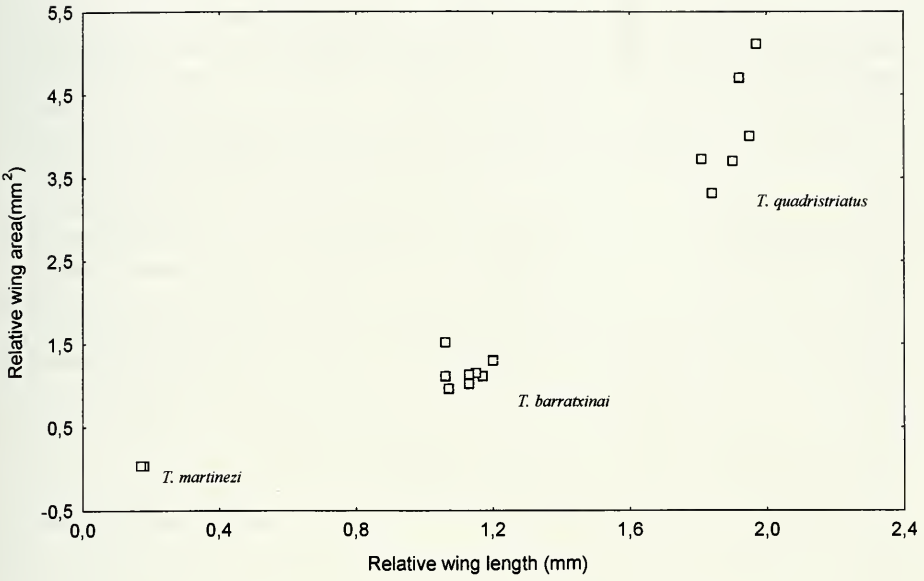

FIG. 5

Wing development in three species of *Trechus*: *T. martinezi* Jeannel, 1927 (species with aborted wings), *T. barratxinai* Español, 1971 (brachypterous species) and *T. quadristriatus* (Schrank, 1781) (species usually with functional wings).

groups, including *T. planipennis*, supposedly the most closely related species. Relationships of *T. varendorffi* Deville, 1903 from Corsica and *T. planipennis* from Sierra Nevada are quite close (demonstrated by several morphological characters and the aedeagus structure due to their common origin in the old Corso-Betican mountain range -Early Oligocene-), and it would not be surprising if, according to taxonomic and geographical criteria, *T. barratxinai* showed a great resemblance and also a certain ecological relationship with the two species mentioned. But on the contrary, there is a great morphological difference between *T. barratxinai* and the species of the *T. pyrenaeus*-group (see above). Probably *T. barratxinai* may in fact be a species of the *Trechus austriacus*-group, with a great morphological resemblance of *T. barratxinai* with *T. diecki* (see below); also, both species are geographical neighbours. The *T. austriacus*-group proposed by Jeannel (1927), at the moment and with some upgrades, is formed by three lineages. A first subgroup is formed by *Trechus crucifer* La Brûlerie, 1875 (different areas in the eastern Mediterranean), *Trechus schmalfussi* Baehr, 1983 (Grecia), *Trechus creticus* Moravec, 2000 (Crete), *Trechus diecki diecki* Putzeys, 1870 (Southern Spain), *Trechus diecki maculipennis* Bedel, 1897 (Algeria) and, as proposed here, *Trechus barratxinai* (Alicante, Spain). A second subgroup, known from the Middle East, is formed by *Trechus saulcyi* Jeannel, 1921, *Trechus libanensis* La Brûlerie, 1875 and *Trechus pamphylicus* Jeanne, 1996. Finally, if we accept the synonymies proposed by Casale & Laneyrie (1982), the third subgroup is monospecific and is formed by *Trechus austriacus* Dejean, 1831, from central and eastern Europe, but also from

Middle East. However, this subgroup should be throughly revised to clarify the status of some taxa synonymised by Casale & Laneyrie (1982) such as: *Trechus subacuminatus* Fleischer, 1898, *Trechus labruleriei* Jeannel, 1921, *Trechus angustus* Sahlberg, 1908 and *Trechus olympicus* La Brulerie, 1876.

Thus, in my opinion, the evidence for a close relationship between *T. barratxinai* and *T. diecki* is rather strong. Many morphological characteristics are common to both species in the same phyletic line, in particular the genital (male and female) anatomy. The aedeagus is almost identical in both species (Figs 3a,c), as well as the parts of the inner sac that show great taxonomic and systematic significance. A supplementary argument for a close relationship between *T. barratxinai* and *T. diecki* is the extraordinary resemblance of the female genitalia in both taxa, in particular in the spermathecal complex (Figs 4b,c): both genitalia have a long, digitiform spermatheca with a diverticulum in the basal tract. On the contrary, *T. plannipennis* shows a more simple structure without diverticulum that, in turn, is different and more complicated than other *Trechus* genitalia (see, e.g., Salgado & Ortuño, 1998).

From all this evidence I propose that the ancestors of *T. barratxinai* took refuge during the Miocene in eastern Iberia. Subsequent climatic changes during periods of high dryness decimated this phyletic line. They found shelter in "area-islands" with high humidity and low temperature, an optimal combination for this hygrophilous species, the Penyes de Roset being one of these refuges (also, other hygrophilous carabids and *Prionoglaris stygia* Enderlein, 1909 a troglophilous Psocoptera, have been located there).

In spite of the taxonomic relationship of *T. barratxinai* and *T. diecki*, it is possible to differentiate both species by the following characteristics: *T. diecki* presents dark pigmentation, tetramaculate elytra, deeper striae (6th and 7th well-defined) and convex interstriae, deeper microreticulation integument (especially in the elytra), shorter tempora and aedeagus with median lobe not very arched; *T. barratxinai* shows unicoloured and depigmented integument, more superficial striae (6th and 7th not well-defined) and not very convex interstriae, shallow microreticulation, longer tempora and, finally, slightly more arched median lobe.

Ecological features

The Penyes de Roset is a very special area in the orography from Alicante province. They are cliff-rocks of calcareous character. Many of the rocky walls collapsed and formed abyss and cracks of tectonic origin. The substrate is very spongy and porous in the base of the cliff-rocks forming screes. This place rises on a vast xeric landscape of the Subcomarca from Canal de Xixona, forming small havens of high humidity and low temperature. In view of these peculiarities, it deserves mention a small list of the more common rupicolous plants: *Hedera helix* L., *Pistacia terebinthus* L., *Umbilicus horizontalis* (Guss.) DC.; *Lavatera maritima* Gouan, *Ruscus aculeatus* L., *Verbascum* sp., *Rosmarinus officinalis* L., *Thymus* sp., and different species of *Asplenium* and *Sempervivum*.

Many geophilic carabids of extreme or limited habitats show stable populations. In these cases dispersal is not necessary and the imagoes fix their brachypterous condition (Darlington, 1943). This same phenomenon occurs in *T. barratxinai*, that has

stabilized the character "reduced wings" (Fig. 5). According to this distribution model we are dealing with a telospecies or senile species (now in contraction; see Rapoport, 1975: 68). *T. barratxinai* is very lucifugous hiding in shady areas and accidentally inside the abyss and cracks. *T. barratxinai* should not be considered as a cavernicolous species (without further qualification) and much less as troglobite (for example, see Jeanne, 1976). In any case, there are reasons to believe that it is a troglophilous species; this eco-physiological trend is favoured by the "pre-adaptation" within this *Trechus* lineage (hygrophilous and lucifugous species), and also by the very cracked substratum with numerous underground refuges. The troglophilous behaviour of *T. barratxinai* also appears in other species of the group (or phyletic line) of *Trechus austriacus*. For example, the epigeous species *T. austriacus* is located in the caves of the Balkan Peninsula (Jeannel, 1941) and Bulgaria (Heynderycx, 1996); *T. saulcyi* appears in caves of Turkey, Syria and Cyprus, occasionally (Decu *et al.*, 2001); *T. diecki* is common, but not exclusive, in the caves of the south-eastern of the Iberian Peninsula (Mateu, 1956; Jeanne, 1967; Tinaut, 1998); Finally, *T. crucifer* is known as troglophilous species in some areas of the southern and northern Mediterranean (Coiffait, 1954; Heynderycx, 1996).

To conclude, *T. barratxinai* is a geophilic, lucifugous and hygrophilous species that, however, lacks important adaptive features to the subterranean environment: the wing is much less reduced than in cavernicolous species, for example *T. martinezi* (Fig. 5). On the other hand, some species have large wings and are capable of flight (*T. quadristriatus*, which exceptionally might be brachypterous) (Fig. 5); the wings of *T. barratxinai* do undoubtedly not allow flight (Fig. 2b, 5). This species has lapidicolous life in fresh and humid places of the Penyes de Roset; in this area the temperature is about 15ºC during summer. The very cracked substratum facilitates colonization of the abyss (specimen of the type series) and the mesocavernous shallow substratum (8 specimens studied in this work). *T. barratxinai* coexists with other species of carabids, e.g. *Carabus (Mesocarabus) helluo* Dejean, 1826, *Orthomus expansus* Mateu, 1952, *Percus (Pseudopercus) guiraoi* Pérez-Arcas, 1869, *Laemostenus (Pristonychus) terricola* (Herbst, 1783), *Platyderus* sp., *Cryptophonus tenebrosus* (Dejean, 1829), *Harpalus (Harpalus) atratus* Latreille, 1804, *Harpalus (Harpalus) wagneri* Schauberger, 1926, *Licinus punctatulus granulatus* Dejean, 1826 and *Brachinus (Brachynidius) sclopeta* (Fabricius, 1792), some of them previously not recorded from the Spanish-Levante.

ACKNOWLEDGEMENTS

I wish to express my thanks to Juan A. Zaragoza for his collaboration in the biospeleological expeditions of 2003 and an anonymous reviewer for helpful comments on a first draft. I also thank Jaime Potti for his revision of the English.

REFERENCES

Bellés, X. 1987. Fauna cavernícola i intersticial de la península ibérica i les illes balears. *CSIC., Ed. Moll, Mallorca*, 207 pp.

Casale, A. & Laneyrie, R. 1982. Trechodinae et Trechinae du Monde. Tableau des sous-familles, tribus, séries phylétiques, genres, et catalogue général des espèces. *Mémoires de Biospéologie* 9: 1-226.

CASALE, A., VIGNA-TAGLIANTI, A. & JUBERTHIE, Ch. 1998. Coleoptera Carabidae (pp. 1047-1081). *In:* JUBERTHIE, C. & DECU, V. (eds). Encyclopaedia Biospéologica. Vol. 2. *Société de Biospéologie, Moulis-Bucarest.*

COIFFAIT, H. 1954. Mission Henri Coiffait au Liban (1951). Coléoptères cavernicoles et endogés. *Archives de Zoologie Expérimentale et Générale* 91(4): 423-436.

DARLINGTON, P.J., Jr. 1943. Carabidae of mountains and islands: data on the evolution of isolated faunas, and on atrophy of wings. *Ecological Monographs* 13: 37-61.

DECU, V., JUBERTHIE, Ch., BAKALOWICZ, M. & TABACARU, I. 2001. Turquie (pp. 2007-2026). *In:* JUBERTHIE, C. & DECU, V. (eds). Encyclopaedia Biospéologica. Vol. 3. *Société de Biospéologie, Moulis-Bucarest.*

DEN BOER, P.J., HUIZEN, T.H.P., DEN BOER-DAANJE, W., AUKEMA, B. & DEN BIEMAN, C.F.M. 1980. Wing polymorphism and dimorphism in ground beetles as stages in an evolutionary process (Coleoptera: Carabidae). *Entomologia Generalis* 6(2-4): 107-134.

ESPAÑOL, F. 1971. Nuevos tréquidos cavernícolas de la fauna española (Col. Caraboidea). *Publicaciones del Instituto de Biología Aplicada de Barcelona* 51: 89-96.

HEYNDERYCX, J. 1996. Les Carabidae troglobies de Bulgarie. *Lambillionea* 96(2): 292-294.

JEANNE, C. 1967. Carabiques de la Péninsule Ibérique (5^{e} note). *Actes de la Société linnéenne de Bordeaux* 104(10), ser. A: 3-22.

JEANNE, C. 1976. Carabiques de la Péninsule Ibérique (2^{e} supplément). *Bulletin de la Société linnéenne de Bordeaux* 6(7-10): 27-46.

JEANNEL, R. 1927. Monografie des Trechinae. Morphologie comparée et distribution géographique d'un groupe de Coléoptères (II livraison). *L'Abeille* 33: 1-592.

JEANNEL, R. 1941. Faune de France, Coléoptères Carabiques, Première Partie. *Lechevalier, Paris*, 571 pp.

LENCINA, J.L., ANDÚJAR, A. & RUANO, L. 1990. Algunas citas de interés de la fauna de coleópteros de la provincia de Albacete. *Revista de Estudios Albacetenses* 27: 101-121.

MATEU, J. 1956. *Atranus collaris* (Menetries) (Col. Carabidae). Género y especie nueva para la fauna española y observaciones sobre carábidos ibéricos. *Eos* 32(1-4): 135-140.

RAPOPORT, E.H. 1975. Aerografía. Estrategias geográficas de las especies. *Fondo de Cultura Económica, México*, 214 pp.

SALGADO, J.M. & ORTUÑO, V.M. 1998. Two new cave-dwelling beetle species (Coleoptera: Carabidae: Trechinae) of the Cantabrian Karst (Spain). *The Colepterists Bulletin* 52(4): 351-362.

SENDRA, A. & ZARAGOZA, J.A. 1982. Invertebrados cavernícolas del País Valenciano. *Lapiaz* 10: 14-22.

SERRANO, J. 2003. Catálogo de los Carabidae (Coleoptera) de la Península Ibérica. Monografías S.E.A. 9. *Sociedad Entomológica Aragonesa, Zaragoza*, 130 pp.

TINAUT, A. 1998. Artrópodos terrestres de las cavidades andaluzas. *Zoologica baetica* 9: 3-28.

ZABALLOS, J.P. & JEANNE, C. 1994. Nuevo catálogo de los carábidos (Coleoptera) de la Península Ibérica. Monografías S.E.A. 1. *Sociedad Entomológica Aragonesa, Zaragoza*, 159 pp.

ZARAGOZA, J.A. & SENDRA, A. 1988. Fauna cavernícola de la provincia de Alicante. Ayudas a la investigación 1984-1985. *Inst. Est. "Juan Gil-Albert". Diputación de Alicante* 3: 11-35.